Comparison of Groombridge's and Struve's Right Ascensions of close Circumpolar Stars. By W. G. Thackeray.

(*Communicated by the Astronomer Royal.*)

How general was the idea that Groombridge's meridian mark was in error is clear from the positive statements made by Dr. Gould in his papers "On the Mean Places of forty-eight Circumpolar Stars," *Astronomical Journal*, Nos. 121, 122, and 130. On p. 1, No. 121, vol. vi., he remarks: "Since there can be no doubt that Groombridge's meridian mark was in error about $2\frac{1}{2}''$," and again on p. 10, No. 122: "right ascensions which, despite the skill and zeal of Piazzi and Groombridge, were referred to erroneous meridian marks." The basis of these positive assertions were the results of the comparison of Struve's and Argelander's observations with those of Groombridge made by Fedorenko and Struve, and which are

$$\text{Argelander-Groombridge} = +0^s\cdot154 + 0^s\cdot188 \tan\delta$$
(Fedorenko, p. 8).

$$\text{Struve-Groombridge} = +0^s\cdot036 + 0^s\cdot130 \tan\delta$$
(Pos. Med. p. cxxviii).

It was Prof. Safford who first (*Monthly Notices*, xlvii. 2, pp. 37–42) sounded a note of doubt on the subject. Dividing the stars common to Struve's and Groombridge's catalogue in four zones he showed that the resulting differences varying but little with the declination, are subject to rather large casual errors, and concluded that "there is but little doubt that the main cause of the discrepancy is instrumental error," and further remarked that "Groombridge's meridian mark was rather too near—about half-mile off—and a previous investigation of Maskelyne's and Pond's observations has shown me that a polar deviation of $\pm 1''$ is not altogether to be avoided when the instrument is adjusted to the meridian from time to time and left for days to its own motions without allowing for azimuth and level error in the modern fashion."

The results of the new reduction of Groombridge's observations for all observations made up to the end of 1810 engrafted on Prof. Safford's paper in the form of corrections conclusively show how right Prof. Safford was in his deductions, and that there is no evidence to support the contention that Groombridge's mark was out of the meridian.

Columns 3 and 4 give respectively the old catalogue and newly reduced place of Groombridge's observations, column 5 the corrections to the old catalogue place, and column 7 the corrected discordance between Struve and Groombridge.

The deduced results of the discussion compare as follows:—

	Mean $\Delta\alpha \times \cos\delta$.	P.E. of one Star.	P.E. of a Groombridge Star.
	s	s	s
Safford original ...	+0·034	±0·093	±0·084
„ corrected ...	−0·026	±0·063	±0·049

The probable error of a Groombridge star was obtained by Professor Safford on the supposition that a liberal allowance for errors of observations in the case of Struve would be $\pm 0^s\cdot04$.

Zone +86° *to* +90°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. $\Delta\alpha$ Struve-Groomb.	Safford. $\Delta\alpha$ corrected.	Safford. $\Delta\alpha \cos\delta$ corrected.
	°	s	s	s	s	s	s
144	2·0	34·75	34·97	+0·22	− 1·82	−2·04	−0·07
235	1·7	37·56	39·10	+1·54	+ 0·40	−1·14	−0·03
642	4·0	6·04	6·04	0·00	− 1·14	−1·14	−0·08
1119	0·9	41·13	31·83	−9·30	−12·05	−2·75	−0·04
1141	2·7	58·61	52·94	−5·67	− 3·73	+1·94	+0·09
1850	3·4	48·47	48·62	+0·15	+ 1·09	+0·94	+0·05
1871	2·5	10·11	7·63	−2·48	− 0·67	+1·81	+0·07
1884	1·3	48·37	42·10	−6·27	− 0·93	+5·34	+0·12
2006	1·4	54·33	58·60	+4·27	+ 3·29	−0·98	−0·02
2065	1·5	55·71	64·64	+8·93	+11·80	+2·87	+0·07
2099	3·4	38·56	41·77	+3·21	+ 3·71	+0·50	+0·03
2210	3·3	22·65	24·07	+1·42	+ 3·88	+2·46	+0·14
2283	2·1	17·78	16·57	−1·21	+ 1·63	+2·84	+0·10
2628	3·4	28·63	29·18	+0·55	+ 0·07	−0·48	−0·03
2667	3·1	44·40	45·81	+1·41	+ 0·45	−0·96	−0·05
3308	1·3	41·23	43·27	+2·04	+ 1·83	−0·21	0·00
3548	3·7	46·98	47·84	+0·86	+ 0·88	+0·02	0·00
4101	3·7	39·78	40·44	+0·66	− 0·35	−1·01	−0·06

Zone +83° *to* +86°.

67	4·7	0·19	2·60	+2·41	+ 0·79	−1·62	−0·13
177	4·8	49·23	49·98	+0·75	+ 0·20	−0·55	−0·04
595	5·8	30·00	31·77	+1·77	+ 2·49	+0·72	+0·07
750	5·0	20·22	21·31	+1·09	+ 0·47	−0·62	−0·05
766	6·7	28·24	29·26	+1·02	+ 0·44	−0·58	−0·06
944	4·9	18·76	18·69	−0·07	− 0·83	−0·76	−0·06
956	4·8	21·23	24·37	+3·14	+ 2·63	−0·51	−0·04
1359	5·4	50·28	46·47	−3·81	− 5·56	−1·75	−0·16
1418	4·3	22·44	18·94	−3·50	− 5·72	−2·22	−0·17

Zone +83° *to* +86°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. Δα Struve-Groomb.	Safford. Δα corrected.	Safford. Δα cos δ corrected.
	°	s	s	s	s	s	s
1620	4·8	56·49	55·78	−0·71	+ 0·47	+1·18	+0·09
1633	6·5	42·14	41·84	−0·30	− 0·33	−0·03	0·00
1889	5·3	26·87	29·29	+2·42	+ 2·91	+0·49	+0·05
1937	5·6	45·56	46·69	+1·13	+ 1·15	+0·02	0·00
1940	5·6	53·71	54·04	+0·73	+ 1·76	+1·03	+0·10
2007	4·3	0·01	1·01	+1·00	+ 1·12	+0·12	+0·01
2063	6·3	23·09	23·49	+0·40	+ 1·24	+0·84	+0·09
2196	6·7	1·86	2·13	+0·27	+ 1·25	+0·98	+0·12
2213	5·3	14·42	15·73	+1·31	+ 1·98	+0·67	+0·06
2315	6·5	3·38	4·69	+1·31	+ 0·83	−0·48	−0·06
2476	6·6	20·33	21·15	+0·82	+ 0·56	−0·26	−0·03
2548	6·6	51·76	51·84	+0·08	− 2·10	−2·18	−0·24
3501	6·5	10·93	11·54	+0·61	− 0·30	−0·91	−0·10
3820	4·8	41·10	42·65	+1·55	+ 0·33	−1·22	−0·10
3824	4·7	18·00	19·81	+1·81	− 0·47	−2·28	−0·18
3970	6·6	27·78	29·65	+1·87	− 0·45	−2·32	−0·27
4193	4·3	57·57	58·90	+1·33	+ 0·20	−1·13	−0·08

Zone +80° *to* +83°.

424	9·6	47·48	48·35	+0·87	+ 0·94	+0·07	+0·01
426	9·4	24·62	25·40	+0·78	+ 1·28	+0·50	+0·08
506	9·2	17·72	17·53	−0·19	− 0·03	+0·16	+0·03
527	9·4	16·32	16·68	+0·36	+ 0·67	+0·31	+0·05
580	9·3	8·73	9·93	+1·20	+ 0·58	−0·62	−0·10
746	9·8	54·54	54·90	+0·36	− 0·05	−0·41	−0·07
774	7·1	22·37	23·27	+0·90	+ 0·43	−0·47	−0·06
779	9·6	37·00	37·30	+0·30	+ 0·47	+0·17	+0·02
785	9·5	48·19	48·94	+0·75	+ 0·52	−0·23	−0·04
856	9·1	19·05	19·82	+0·77	+ 0·99	+0·22	+0·03
1255	8·4	48·24	48·32	+0·08	− 1·17	−1·25	−0·18
1259	7·3	22·39	23·24	+0·85	+ 0·54	−0·31	−0·04
1278	8·8	30·12	30·45	+0·33	− 0·49	−0·82	−0·13
1339	9·3	17·77	17·49	−0·28	− 0·50	−0·22	−0·03
1355	9·7	4·96	6·19	+1·23	+ 0·56	−0·67	−0·12
1391	7·0	36·57	35·81	−0·76	− 0·85	−0·09	−0·01
1431	7·1	49·82	49·70	−0·12	− 1·81	−1·69	−0·21

Zone +80° *to* +83°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. Δα Struve-Groomb.	Safford. Δα corrected.	Safford. Δ cos δ corrected.
	°	s	s	s	s	s	s
1452	9·3	21·70	22·30	+0·60	− 0·56	−1·16	−0·19
1463	9·3	49·55	49·71	+0·16	− 0·83	−0·99	−0·16
1480	8·5	52·89	54·12	+1·23	− 0·08	−1·31	−0·19
1537	7·9	57·35	56·77	−0·58	− 1·46	−0·88	−0·12
1643	8·6	41·61	40·60	−1·01	− 0·85	+0·16	+0·02
1662	8·6	0·59	0·58	−0·01	− 0·36	−0·35	−0·05
1778	7·9	56·30	57·43	+1·13	+ 1·01	−0·12	−0·02
1782	7·9	55·13	55·33	+0·20	− 0·07	−0·27	−0·04
1845	8·1	3·92	4·58	+0·66	+ 1·86	+1·20	+0·18
1858	7·3	12·62	12·01	−0·61	− 0·13	+0·48	+0·06
1909	8·7	11·13	11·93	+0·80	+ 1·31	+0·51	+0·08
1927	8·4	35·80	36·07	+0·27	+ 1·34	+1·07	+0·16
1977	8·5	53·10	52·90	−0·20	+ 0·15	+0·35	+0·05
2037	8·7	46·07	46·30	+0·23	+ 0·05	−0·18	−0·03
2071	8·3	8·70	8·77	+0·07	+ 0·80	+0·73	+0·11
2275	9·0	41·80	42·65	+0·85	+ 1·93	+1·08	+0·17
2276	9·0	54·46	55·27	+0·81	+ 2·06	+1·25	+0·20
2422	7·7	51·28	52·02	+0·74	+ 0·29	−0·45	−0·06
2456	9·7	8·95	9·13	+0·18	+ 0·23	+0·05	+0·01
3268	9·2	17·30	17·52	+0·22	+ 0·40	+0·18	+0·03
3276	9·2	36 30	37·02	+0·72	+ 0·43	−0·29	−0·05
3277	9·6	55·19	55·65	+0·46	+ 0·33	−0·13	−0·02
3370	8·2	35·07	36·14	+1·07	+ 0·85	−0·22	−0·03
3707	8·4	25·24	25·71	+0·47	+ 0·23	−0·24	−0·04
3709	8·4	31·26	31·95	+0·69	+ 0·79	+0·10	+0·01
3887	9·6	46·32	47·37	+1·05	− 0·10	−1·15	−0·19
3928	7·8	52·99	54·19	+1·20	− 0·30	−1·50	−0·20

Zone +70° *to* +80°.

616	13·0	40·30	41·36	+1·06	+ 0·53	−0·53	−0·11
919	11·0	29·89	30·98	+1·09	+ 0·71	−0·38	−0·07
966	15·1	23·25	24·24	+0·99	+ 0·69	−0·30	−0·08
1217	12·8	9·94	10·97	+1·03	+ 0·63	−0·40	−0·09
1562	10·0	4·31	4·31	0·00	− 0·71	−0·71	−0·12
1650	13·3	33·02	35·18	+2·16	+ 0·98	−1·18	−0·26
1859	11·4	6·87	7·57	+0·70	+ 0·58	−0·12	−0·02

Zone +70° *to* +80°.

Groomb. No.	Polar Dist.	Secs. of Groomb. Old.	Secs. of Groomb. New.	New minus Old.	Safford. Δα Struve-Groomb.	Safford. Δα corrected.	Safford. Δα cos δ corrected.
	°	s	s	s	s	s	s
2094	11·6	47·11	47·06	−0·05	+ 0·10	+0·15	+0·03
2130	13·5	4·45	4·27	−0·18	+ 0·21	+0·39	+0·09
2172	15·1	22·80	23·35	+0·55	+ 0·65	+0·10	+0·02
2228	17·5	20·17	20·43	+0·26	− 0·09	−0·35	−0·10
2236	17·5	6·78	7·53	+0·75	+ 0·55	−0·20	−0·06
2268	12·0	16·82	18·16	+1·34	+ 1·46	+0·12	+0·02
2294	11·6	4·97	6·33	+1·06	+ 1·39	+0·33	+0·07
2334	13·7	23·80	24·15	+0·35	+ 0·28	−0·07	−0·01
2336	14·3	28·15	27·53	−0·62	− 0·69	−0·07	−0·01
2349	13·8	11·45	12·25	+0·80	+ 0·67	−0·13	−0·03
2475	17·8	20·32	20·46	+0·14	0·00	−0·14	−0·04
2477	17·8	22·04	22·10	+0·06	− 0·06	−0·12	−0·04
2546	10·0	17·75	12·82	−4·93	(− 4·92)	+0·01	0·00
2547	10·0	24·21	19·29	−4·92	(− 4·98)	−0·06	−0·01
2726	14·8	25·66	25·99	+0·33	+ 0·08	−0·25	−0·06
2930	16·0	1·14	1·72	+0·58	+ 0·43	−0·15	−0·04
3148	12·9	3·00	3·31	+0·31	+ 0·43	+0·12	+0·03
3373	10·1	48·72	48·10	−0·62	− 1·16	−0·54	−0·09
3419	12·6	3·55	4·17	+0·62	+ 0·16	−0·46	−0·10
3508	14·4	8·39	7·96	−0·43	− 0·75	−0·32	−0·08
3511	10·3	0·18	1·47	+1·29	+ 1·74	+0·45	+0·08
3809	12·2	9·65	8·86	−0·79	− 0·71	+0·08	+0·02
3831	12·1	5·42	4·51	−0·91	− 0·82	+0·09	+0·02
3834	14·7	53·22	...	...	− 0·74	...	...
4122	13·4	38·70	38·61	−0·09	− 0·04	+0·05	+0·01

From an independent comparison of the individual observations of some 35 stars spread over the four zones as shown below the p.e. of a Groombridge observation is $\pm 0^{s}\cdot053$:—

Zone.	East.	Wt.	No. of Stars.	West.	Wt.	No. of Stars.
° °	s			s		
90–86	±0·031	14	3	±0·047	28	5
86–83	±0·066	23	5	±0·056	12	3
83–80	±0·070	20	5	±0·061	23	5
80–70	±0·055	14	3	±0·062	28	6

The Distribution of the Stars of the Cape Photographic Durchmusterung. By A. M. W. Downing, D.Sc., F.R.S.

The publication of the C.P.D. is of peculiar interest as enabling us, for the first time, to attack the problem of stellar distribution on a sufficiently extended scale by a method which is free from many of the disabilities attaching to the older method of eye observing, although liable to other disabilities which affect the photographic method.

Thus the photographic plate is far more efficient than the eye in registering the stars to the same order of magnitude in the richer portions of the sky as in more sparsely occupied regions. On the other hand, the determination of a homogeneous system of stellar magnitudes by photography is a difficult and delicate operation.

Notwithstanding, therefore, the fact that M. Stratonoff has already published an instructive note on the subject in *Astron. Nachrichten*, No. 3710, I have thought that it would be of interest to astronomers to exhibit the general results of an analysis of the C.P.D. which I have made pending the publication of a further discussion of the registered stellar magnitudes which is expected from the authors, more especially as my work is carried out on somewhat different lines from those adopted by M. Stratonoff. In what follows the magnitudes of the catalogue are adopted throughout.

I have omitted the partial zone $-18°$, so that the stars whose distribution is here discussed all lie between $-19°$ dec. and the South Pole (Equinox 1875·0).

The first, and of course by far the most laborious, part of the work was to count the stars of different magnitudes occurring in each zone. The magnitude-groups adopted were (1) 0 to 6·2, (2) 6·3 to 6·7, (3) 6·8 to 7·2, (4) 7·3 to 7·7, (5) 7·8 to 8·2, (6) 8·3 to 8·7, (7) 8·8 to 9·2, (8) 9·3 to 9·7, (9) 9·8 to 10·2, and (10) 10·3 and fainter. The numbers in the last group were formed by simply taking the differences between the sums of the first nine groups and the total numbers for each zone. The group is relatively too limited in numbers of stars to be of interest to us in the present connection.

In order to avoid the inconvenience of using large numbers I have exhibited the results of the counts as "density," or number of stars in one square degree.

The first table gives the mean density corresponding to each magnitude-group and the ratio (ρ), corresponding to one stellar magnitude computed from the expression

$$n \log \rho = \log D_{m+n} - \log D_m$$

where D_{m+n} is the density from magnitude 0 to magnitude $m+n$, and D_m is the similar density to magnitude m.